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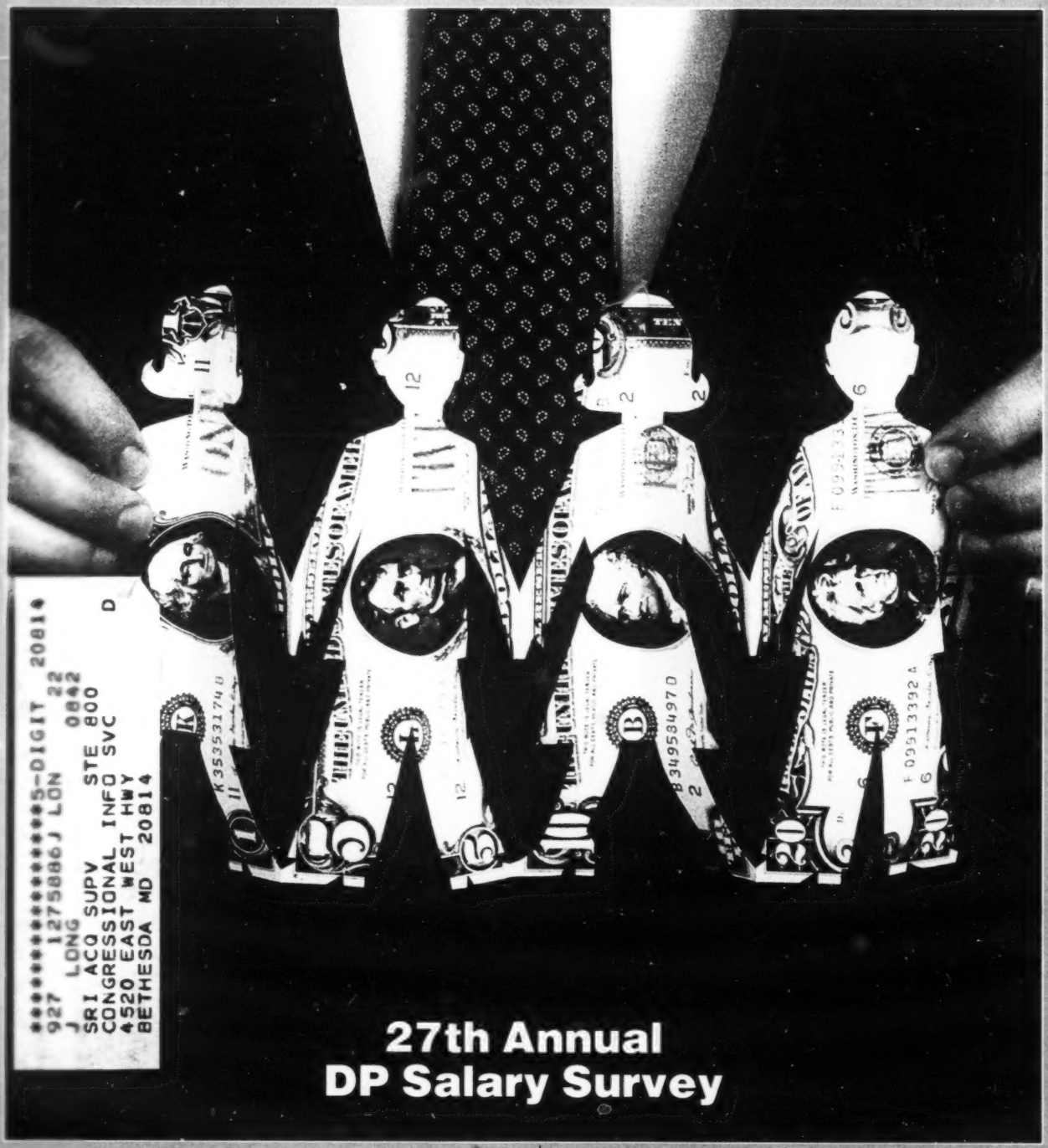
June 1985

INFOSYSTEMS

New Economics of Computers • Programmer Productivity Tools

Guidelines for CAD/CAM • PCs: Tools or Toys?

Multifunction Workstations • The Information Center • MIS Planning



27th Annual DP Salary Survey

INFOSYSTEMS

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27

56

40

59

FEATURES

24
Inforum: **Fitting IS into the Organization**

27
27th Annual DP Salary Survey: **Prosperity Continues**

40
Installing a Solution Center: Think Big, Start Small
In a center that provides access to corporate information resources, end users can do their own information processing with professional support.

46
Dialing for Data with Multifunction Workstations
Common to all IVDTs is software technology that serves as a distributed operating system for voice and data communications.

50
Snyders on Software: **The Nth Version of Software**

52
The Science of MIS Planning
If personnel and staffing costs are not accurately projected, the entire department's budget is in jeopardy.

54
Technology Info: **One More Step for Unix**

56
Evaluating CAD/CAM Systems: Priorities & Integration
Computer-aided design/computer-aided manufacturing systems can have a startling effect on fundamental business elements.

59
The Benefits of Programmer Productivity Software
With the right tools, MIS managers can convert from one system to another, modify old systems, and even train new employees in a quick and cost-effective way.

66
The New Economics of Computers
Although earlier predictions have been off the mark, two things are certain: the cost of electronic circuitry continues to fall, and the market for computers continues to soar.

85
Spotlight: **Is Voice Messaging Still on Hold?**

92
For the Sake of Security: **Protection on the PC**

96
Personal Computers: Management Tools or Executive Toys?
PCs can be used to the best advantage if they are implemented to accomplish business objectives.

INSIDE INFO

14 IS executives may find themselves assuaging an end-user revolt
16 Amway-style marketing approach could help limit software piracy
17 Special talents evident in maintenance programming
18 CBT can exhilarate users once they know how to 'fall down'
19 US industry's ability to compete declining, commission says

DEPARTMENTS

8 Feedback
10 Editor's Perspective
20 Arnie
100 Products/Services Info
108 Ad Index

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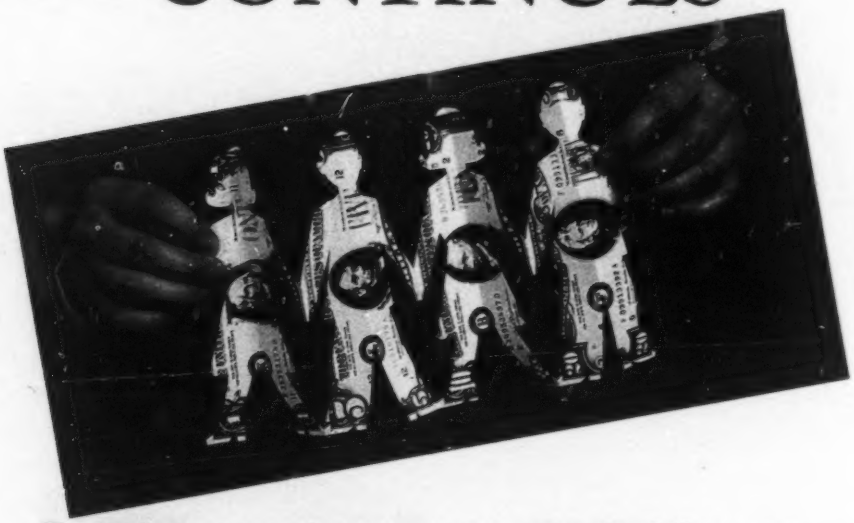
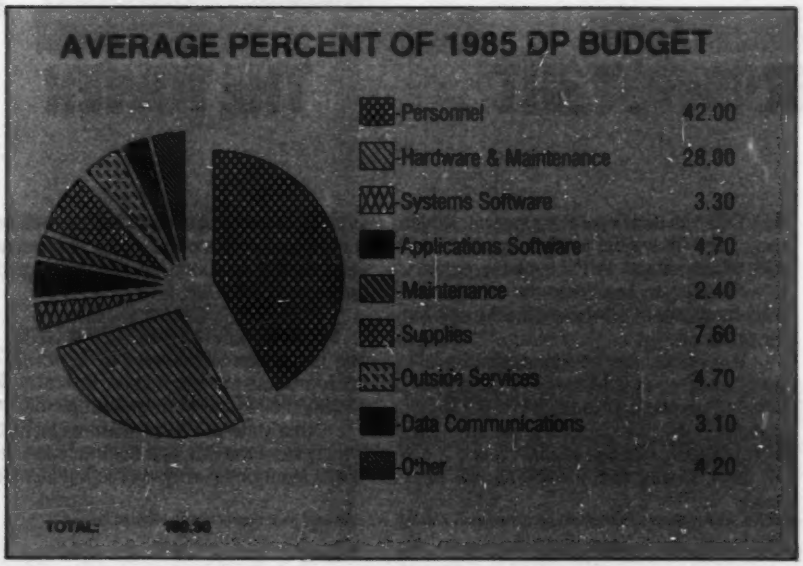
PROSPERITY CONTINUES



Data base systems managers led the way as data processing salaries rose an average of almost eight percent.

By Chuck Cozette, Associate Editor



If money talks, then the creation and maintenance of strategic data bases is becoming an increasingly critical priority in corporate data center operations.

The individual charged with this responsibility, the data base systems manager, led all job titles in percentage salary increase, according to INFOSYSTEMS' 27th Annual Data Processing Salary Survey. Data base managers' salaries rose 21 percent to an average of $849 a week, up almost $150 a week from last year's levels.

It was also a good year for lead and senior analysts/programmers, most of whom received salary increases ranging from 9 to 17 percent. The average increase for all data processing (DP) job titles was about eight percent, a full percentage point higher than last year.

Public utilities, insurance firms and DP service companies were among the

27th Annual DP Salary Survey

highest paying employers. DP personnel in the field of education continued to receive the lowest pay levels.

The 1985 survey is based on responses from 790 firms drawn from the top 50 US metropolitan areas according to computer installations and usage. The respondents reported on 8,863 full-time positions. The survey, conducted by Hitchcock Marketing Services, Wheaton, IL, reflects salaries in effect on March 1, not including bonuses or other benefits.

Average salaries for top management information systems (MIS) officials and DP managers rose less than the industry average: MIS managers up three percent to $1,062 a week, and DP managers up four percent to $752 a week. The highest salary reported for a MIS officer was $2,308 a week, or about $120,000 per year.

The average assistant DP manager's salary, up 13 percent, was only one dollar less than that of the average DP manager. These figures are somewhat misleading, however, because the position of assistant DP manager is usually limited to larger firms with correspondingly bigger DP departments and budgets, explained Ray Winkler, manager of market research at Hitchcock. The salary average for the DP manager, on the other hand, is "diluted" by responses from small companies, some of which have only one or two people in their DP departments. The scope of these managers' responsibilities, and their corresponding salaries, are often less than that of an assistant manager at a large firm.

As might be expected, geographic location had a significant influence on salary levels. Firms in regions in the country lacking in major metropolitan areas reported notably lower salaries than regions with higher concentrations of urban areas. Average salaries for DP personnel in the West North Central states (MN, ND, SD, NB, IA) ranked last among geographic areas in 21 of the 36 job titles. Salary levels in East South Central states (KY, TN, MS, AL) were below the national average for all but two job titles.

DP personnel working in cities also averaged six percent higher salaries than their suburban counterparts, although this is down from seven percent last year. In New York City, where salaries are among the highest in the country, the city/suburban differential fell from 13 percent to nine percent. In sprawling Los Angeles, where city/suburban boundaries are far less defined, the salary differential was only three percent.

In addition to salary information, the survey gathered data about staffing, budgeting and computer operations.

The average number of employees in DP departments remained stable at 20. This number of employees would correspond to a company with between 1,800 and 1,900 total employees and the rental equivalent of about $50,000 in monthly equipment costs, according to the survey. Companies spending $150,000 or more per month for equipment averaged almost 180 DP employees.

Finding and retaining DP personnel continues to be a challenge, as almost 60 percent of survey respondents reported turnover in their departments. More than one in seven DP employees were new to their jobs, compared to almost one in eight last year when only 50 percent of survey respondents reported turnover. With 27 percent of respondents reporting salaried, nonclerical departmental vacancies, this job turnover is likely to continue. Companies with vacancies reported an average of more than three unfilled positions, up from an average of two last year.

More than two-thirds of full-time DP personnel are salaried. The remaining 30 percent work on an hourly basis, according to the survey. Of those companies that had hourly, full-time DP personnel, an average of six percent of related costs were for overtime.

The percentage of overall DP budget spent for personnel remained steady at 42 percent. Expenditures for personnel have dropped only slightly during the last five years, from a high of 45 percent of total budget in 1980.

Software continued to claim an increasingly larger portion of the DP budget while hardware expenditures continued to decline. Software represented 10 percent of the average DP budget, almost half of which was allocated for application software. Average hardware expenditures decreased a fraction of a percentage point to 28 percent of the total DP budget: 11 percent of which was spent on computers, 10 percent for maintenance and 7 percent for peripherals.

The financial officer remained DP's primary link to corporate management. Thirty-eight percent of respondents indicated their DP manager reported to the controller or treasurer; 33 percent to the president, owner or general manager; 11 percent to a vice president; and 9 percent to the MIS director.

Two key issues facing most DP departments are data security and centralized control of microcomputers. Of the 57 percent of respondents indicating centralized control for microcomputer acquisition and implementation within their companies, two-thirds said budgetary responsibility rested with DP or MIS management. Less than two percent of survey respondents said they have a full-time data security specialist on staff. Eleven percent indicated having a part-time data security specialist.

Salary Breakout

A comprehensive breakout of salary information can be found in chart form on the following pages: by geographic area, page 32; by size of installation, page 37; and by industry, page 38. (N)

For an extra copy of this article, please enter No. 12 on the Reader Information Card.

Number of Employees in DP vs. Company

(By Equipment Rental Range)

Rental Range Per Month	Average Number In DP	Average Number In Company
Under $3,000	4.7	294.8
$3,000 To $4,499	5.9	208.8
$4,500 To $5,999	6.5	362.9
$6,000 To $8,999	7.2	405.8
$9,000 To $11,999	8.4	472.5
$12,000 To $14,999	8.4	584.8
$15,000 To $17,999	11.0	888.6
$18,000 To $24,999	13.9	721.5
$25,000 To $49,999	18.0	1781.6
$50,000 To $74,999	28.4	2053.6
$75,000 To $99,999	43.0	2396.7
$100,000 To $149,999	67.3	2811.2
$150,00 And Over	179.8	7225.4
Not Available	41.6	2130.2
All Companies	18.5	1042.6

Job Descriptions Available

Detailed job descriptions for the 36 DP positions surveyed are available free of charge. For a copy, enter No. 138 on the Reader Information Card.

Complete DP Salary Survey

A complete copy of the INFOSYSTEMS 1985 DP Salary Survey can be ordered for $195. The report includes replies to the 18 questions in the study by industry and equipment rental range, as well as salary data for the 36 job functions. Send your check or company purchase order to Hitchcock Executive Book Service, Hitchcock Building, 25W550 Geneva Road, Wheaton, IL 60188.

27th Annual DP Salary Survey

Average Reported Weekly Salaries by Geographic Area

Job Description	Job Code	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	National Average 1984	National Average 1985	% Increase/Decrease
MANAGEMENT		(34)	(118)	(91)	(199)	(16)	(70)	(65)	(29)	(112)	(905)	(745)	—(No. Firms)
Top MIS Official	(01)	1175	1047	1093	1034	940	1042	1188	1055	1035	1029	1062	+3.2
Data Base Systems	(02)	740	962	764	805	849	882	795	772	723	702	849	+20.9
Data Processing	(03)	815	753	720	744	758	694	806	821	760	721	752	+4.3
Ass't. DP	(04)	783	684	732	785	693	744	678	729	750	663	751	+13.3
[illegible]													
[illegible]	(05)	717	847	853	783	632	778	819	855	881	787	753	+4.1
Systems Analysis and Programming													
Manager/Supervisor	(06)	788	851	689	764	648	706	762	795	764	732	751	+2.6
Lead	(07)	675	656	677	696	535	639	683	679	605	613	664	+8.3
Senior	(08)	579	606	560	600	499	526	601	666	599	550	646	+17.5
Junior	(09)	497	565	457	541	365	483	552	502	439	445	517	+16.2
[illegible]													
[illegible]	(10)	753	915	788	787	798	707	913	860	876	779	859	+7.5
[illegible]	(11)	691	722	730	750	700	666	731	754	743	611	710	+16.2
[illegible]	(12)	577	660	632	621	619	613	590	544	621	591	616	+4.2
[illegible]	(13)	561	501	548	561	576	534	524	529	512	520	547	+5.2
Systems Programming													
Manager/Supervisor	(20)	889	853	745	763	769	770	798	873	765	743	784	+5.5
Lead	(21)	742	765	704	730	624	664	689	767	669	644	737	+14.4
Senior	(22)	613	656	607	600	568	619	663	655	622	573	627	+9.4
Junior	(23)	509	544	560	510	**	465	594	524	476	444	524	+18.0
Trainee	(24)	430	500	446	502	440	326	419	487	456	344	466	+35.5
[illegible]													
[illegible]	(25)	680	677	647	687	574	634	755	738	562	709	644	−6.8
[illegible]	(26)	624	640	641	647	469	552	625	658	573	545	606	+11.2
[illegible]	(27)	520	563	508	572	413	448	496	588	546	467	509	+9.0
[illegible]	(28)	421	436	430	424	320	392	476	479	413	392	450	+14.8
[illegible]	(29)	333	329	367	334	280	317	355	390	380	298	344	+15.5
Data Communications													
Manager	(30)	615	511	568	592	600	582	664	679	757	612	618	+1.0
Operator	(31)	372	422	362	478	405	400	503	449	395	390	431	+10.5
[illegible]													
[illegible]	(32)	503	539	532	496	427	528	572	547	602	531	532	+0.2
[illegible]	(33)	365	446	398	375	335	356	412	414	407	382	396	+3.7
[illegible]	(34)	337	376	348	353	320	326	349	385	390	340	358	+5.3
[illegible]	(35)	272	280	307	280	253	282	298	308	317	282	297	+5.3
I/O Control Manager	(36)	348	347	394	419	295	402	356	318	380	366	372	+1.6
Tape Librarian	(40)	278	272	298	334	275	275	284	331	300	301	297	−1.3
[illegible]	(41)	512	545	533	476	425	344	402	491	516	78	450	——
Data Entry													
Supervisor	(42)	407	365	380	373	361	371	363	401	415	362	375	+3.6
Lead Operator	(43)	294	280	311	318	297	288	298	273	334	294	301	+2.4
Senior Operator	(44)	281	254	307	273	223	251	248	309	311	277	271	−2.2
Junior Operator	(45)	222	222	264	239	165	232	242	289	280	218	241	+10.6

NI = Not included **Indicates insufficient information available

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Weekly Salaries for All Jobs: Nationwide and by Size of Installation

Job Description	Job Code	NATIONAL STATISTICS: Number Reported	Lowest Reported Actual Salary	25th Percentile* Actual Salary	National Average Actual Salary	Median* Actual Salary	Mode* Actual Salary	75th Percentile* Actual Salary	Highest Reported Actual Salary	Established Salary Range—Average Low	Established Salary Range—Average High	AVERAGE SALARY—BY EQUIPMENT RENTAL RANGE: Under $3,000/Mo.	$3,000-4,499/Mo.	$4,500-5,999/Mo.	$6,000-8,999/Mo.	$9,000-11,999/Mo.	$12,000-14,999/Mo.	$15,000-17,999/Mo.	$18,000-24,999/Mo.	$25,000-49,999/Mo.	$50,000-74,999/Mo.	$75,000-99,999/Mo.	$100,000-149,999/Mo.	$150,000 and over
MANAGEMENT												(112)	(90)	(62)	(86)	(61)	(45)	(39)	(47)	(82)	(41)	(16)	(15)	(34)
Top MIS Official	(01)	177	461	923	1062	996	923	1211	2308	907	1239	991	1009	1035	983	1035	947	1020	1040	1039	1050	1098	1204	1445
Data Base Systems	(02)	55	385	684	849	828	961	1057	1500	684	1020	690	701	**	**	**	707	**	623	792	793	746	752	1108
Data Processing	(03)	581	307	615	752	759	865	884	1384	627	901	605	640	688	720	768	779	785	792	841	880	890	906	1055
Ass't. DP	(04)	101	346	657	751	782	1076	907	1192	584	839	600	603	663	664	746	**	699	754	798	784	853	887	953
Project/Team Leader																								
Leader	(05)	278	413	673	783	787	908	975	1019	572	838	413	582	547	541	624	517	735	702	707	685	719	827	834
Systems Analysis and Programming																								
Manager/Supervisor	(06)	239	346	644	751	738	673	865	1586	620	904	651	739	606	624	648	709	680	705	698	802	791	828	846
Lead	(07)	264	317	576	664	667	826	769	1026	529	732	597	707	527	606	568	629	636	585	665	615	673	802	795
Senior	(08)	799	346	542	646	673	757	757	923	484	682	566	634	506	548	566	565	579	565	604	580	557	612	718
Junior	(09)	464	259	434	517	528	626	626	769	396	561	490	578	382	477	408	378	407	443	470	474	453	561	600
Systems Analyst																								
Manager/Supervisor	(10)	36	450	699	859	807	1076	1076	1211	610	869	690	**	**	**	**	**	**	725	**	765	**	782	1030
Lead	(11)	88	442	650	710	710	807	807	1000	585	817	640	**	**	543	**	609	**	625	682	723	**	752	731
Senior	(12)	156	268	553	616	617	634	665	961	493	714	544	**	**	518	486	**	632	622	635	618	654	673	667
Junior	(13)	67	220	473	547	543	626	618	770	441	647	432	**	**	450	477	420	**	471	485	507	543	541	727
Systems Programming																								
Manager/Supervisor	(20)	76	365	705	784	778	769	865	1153	668	967	**	**	**	**	**	**	**	729	788	748	769	827	874
Lead	(21)	84	489	635	737	716	750	826	1211	571	819	614	**	**	**	**	**	**	**	617	646	726	751	828
Senior	(22)	154	270	543	627	640	673	702	961	513	735	579	533	**	497	458	478	**	507	544	618	688	728	755
Junior	(23)	131	270	423	524	528	626	626	788	434	620	496	437	**	396	399	374	393	488	485	522	557	627	533
Trainee	(24)	46	259	373	466	469	559	559	646	395	557	458	**	**	**	370	369	**	336	372	**	496	**	521
Application Programming																								
Manager/Supervisor	(25)	78	346	530	664	676	807	761	1201	583	819	538	**	**	**	642	564	579	680	707	679	696	846	711
Lead	(26)	262	307	500	606	592	768	693	969	485	715	490	505	538	504	550	557	562	606	591	598	568	728	623
Senior	(27)	557	250	442	509	500	482	557	865	426	603	476	468	503	443	485	430	448	466	538	513	483	630	541
Junior	(28)	555	200	370	450	423	461	489	353	354	511	415	457	387	342	356	372	400	377	436	413	399	517	451
Trainee	(29)	168	154	281	344	340	376	364	514	294	426	339	285	270	237	259	246	262	305	368	335	331	393	395
Data Communications																								
Manager	(30)	36	320	489	618	615	615	758	1057	507	712	**	**	**	**	320	**	475	**	689	474	639	736	703
Operator	(31)	70	200	346	431	386	384	478	965	375	536	327	**	380	**	374	**	323	324	449	408	428	497	485
Computer Operations																								
Manager/Supervisor	(32)	301	211	423	532	525	384	655	1188	466	670	605	444	406	472	482	486	448	583	542	593	638	596	644
Lead Operator	(33)	373	193	326	396	376	384	449	875	329	461	386	334	321	369	360	373	355	356	372	401	452	466	533
Senior Operator	(34)	630	153	302	385	345	346	389	750	299	416	344	318	310	320	354	353	316	340	369	370	358	424	374
Junior Operator	(35)	584	150	250	297	288	288	346	500	230	353	250	257	268	275	282	308	242	272	288	276	325	353	331
I/O Control Manager	(36)	129	200	296	376	346	325	428	739	335	483	368	**	314	326	333	343	335	347	371	368	375	389	508
Tape Librarian	(40)	57	192	258	287	296	230	340	443	261	374	333	**	**	302	**	**	**	287	281	315	301	292	298
User Training Specialist	(41)	69	211	384	453	447	403	530	882	368	605	478	367	**	391	423	443	**	**	481	482	436	**	468
Data Entry																								
Supervisor	(42)	110	226	300	375	362	346	432	633	320	458	358	311	357	344	316	352	409	392	372	399	386	417	441
Lead Operator	(43)	212	184	260	301	300	288	342	548	257	361	264	269	318	301	314	326	318	320	290	305	321	324	359
Senior Operator	(44)	581	150	230	271	262	210	300	500	231	320	243	249	304	254	271	241	277	273	279	285	268	298	303
Junior Operator	(45)	235	144	204	241	240	230	276	442	201	282	233	224	226	242	210	217	219	228	243	259	260	266	280

*Median—A figure having an equal number above and below
*Mode—The salary reported most often
*25th Percentile—That point at which 25% of all other salaries are lower and 75% are higher
*75th Percentile—That point at which 75% of all other salaries are lower and 25% are higher

**Indicates insufficient information available

27th Annual DP Salary Survey

Average Reported Weekly Salaries by Industry

Job Description	Job Code																							
MANAGEMENT		(17)	(21)	(55)	(18)	(71)	(28)	(32)	(27)	(10)	(27)	(42)	(72)	(18)	(50)	(43)	(19)	(40)	(39)	(10)	(19)	(26)	(13)	(48)
Top MIS Official	(01)	1140	1180	869	1060	1054	1052	1165	1001	1326	1168	1050	1108	828	1053	1052	999	982	990	1038	**	1213	1154	1045
Data Base Systems	(02)	**	**	660	605	874	691	739	**	812	807	980	615	**	835	892	630	**	**	**	**	795	**	**
Data Processing	(03)	746	856	643	665	776	801	763	686	922	712	869	726	761	707	749	723	793	744	750	738	812	730	767
Ass't. DP	(04)	708	759	635	645	756	790	762	597	902	684	868	641	741	693	740	**	786	730	**	**	**	**	**
Project/Team Leader																								
Leader	(05)	853	728	709	**	718	768	787	631	785	655	752	851	757	744	712	**	704	818	**	**	772	729	819
Systems Analysis and Programming																								
Manager/Supervisor	(06)	818	805	599	725	702	760	755	**	828	802	771	786	743	695	774	693	779	709	**	**	691	**	819
Lead	(07)	722	591	517	632	669	540	711	**	785	684	707	678	656	583	625	614	670	619	634	596	656	**	672
Senior	(08)	608	553	506	606	541	521	569	592	754	610	682	481	595	547	585	605	617	590	**	577	627	559	638
Junior	(09)	466	466	452	500	406	385	530	**	625	481	605	441	527	450	380	590	453	530	**	**	537	432	573
Systems Analysis																								
Manager/Supervisor	(10)	**	781	**	**	841	**	733	**	876	**	**	619	**	754	785	**	**	**	**	**	**	**	**
Lead	(11)	**	718	**	**	686	694	706	**	816	**	**	597	**	**	692	725	**	613	**	**	**	**	**
Senior	(12)	624	619	471	480	569	592	698	**	796	566	610	564	616	**	590	659	568	604	**	**	**	**	**
Junior	(13)	**	573	441	**	527	561	540	437	642	**	525	**	563	**	467	**	418	**	**	**	**	**	**
Systems Programming																								
Manager/Supervisor	(20)	**	809	**	884	756	**	787	**	810	805	841	768	774	**	757	788	761	**	**	**	802	**	972
Lead	(21)	**	688	623	**	721	755	723	**	760	680	801	730	677	**	708	**	717	661	**	**	720	**	931
Senior	(22)	**	568	497	**	608	625	685	**	738	593	631	650	544	595	**	**	639	580	653	**	657	646	687
Junior	(23)	**	**	485	576	492	461	602	**	605	454	564	507	505	397	502	**	**	468	**	**	613	560	**
Trainee	(24)	**	**	307	**	419	408	384	**	541	**	496	448	**	**	424	**	307	**	**	**	**	**	**
Applications Programming																								
Manager/Supervisor	(25)	**	734	561	**	634	680	757	663	**	**	730	690	**	**	746	**	593	**	744	**	655	**	721
Lead	(26)	460	587	526	544	603	658	662	**	651	**	660	632	**	**	624	653	564	527	**	**	533	**	570
Senior	(27)	470	478	468	451	538	548	529	598	599	493	542	487	410	494	524	582	476	518	566	539	469	459	472
Junior	(28)	364	395	416	424	423	482	482	374	541	356	467	430	339	373	424	426	377	385	419	**	446	493	463
Trainee	(29)	328	297	308	346	354	403	353	345	464	326	299	285	**	279	304	332	331	388	304	**	336	**	361
Data Communications																								
Manager	(30)	**	517	480	**	540	596	618	**	**	**	718	**	543	**	**	**	**	**	**	**	**	**	**
Operator	(31)	381	350	**	**	400	408	398	384	**	**	442	**	470	**	456	**	**	301	**	**	**	**	**
Computer Operations																								
Manager/Supervisor	(32)	501	524	457	434	617	498	554	525	606	546	556	499	546	494	556	393	475	546	610	**	625	502	583
Lead Operator	(33)	382	332	350	357	450	441	402	346	530	421	417	347	447	357	413	359	397	347	454	353	396	349	416
Senior Operator	(34)	369	318	338	333	373	393	375	339	501	300	353	331	432	313	392	362	339	327	321	327	342	315	377
Junior Operator	(35)	253	250	284	279	317	335	345	258	336	280	263	274	301	259	268	246	273	285	260	284	299	280	314
I/O Control Manager	(36)	354	460	373	288	407	405	327	298	398	336	403	357	476	275	399	230	451	341	373	**	352	**	391
Tape Librarian	(40)	332	**	285	**	306	**	263	288	350	318	305	253	368	**	334	**	300	**	**	**	288	**	**
User Training Specialist	(41)	428	429	448	**	362	456	494	624	398	**	476	469	**	526	**	**	**	**	**	**	359	**	**
Data Entry																								
Supervisor	(42)	390	379	281	310	397	307	280	349	330	315	382	380	344	358	376	351	401	359	366	389	358	318	384
Lead Operator	(43)	358	298	276	279	314	289	253	265	277	279	314	311	314	304	315	326	318	289	295	319	306	288	307
Senior Operator	(44)	307	247	265	220	283	277	244	251	251	252	237	281	245	259	270	320	267	283	265	294	287	273	259
Junior Operator	(45)	263	188	260	214	267	270	232	206	226	227	225	231	240	233	223	252	242	251	205	232	247	220	234

Manufacturing and Processing

(No. Firms)

**Indicates insufficient information available

The New Economics of Computers

In the 1960s and early 1970s, two economic laws reigned supreme in the world of computers. The first, relating to economies of scale, stated that the larger the computer, the better its price/performance. The second applied to large systems shared by many users—the norm at that time—and stated that economies of scope were to be gained from sharing software and support resources among similar applications.

These economic laws no longer apply to many recently introduced computers and applications. Economies of scale may still apply, but only within narrow categories of equipment. With the economies derived from large-volume production of integrated circuit chips, microcomputers and superminicomputers often show better price/performance than the large machines.

The earlier benefits of spreading the costs of software and support among many users via timesharing are being challenged by inexpensive microcomputers that provide relatively cheap, easy-to-use software packages and are operated by novice users. At the same time, applications most suited to large computers, such as high-volume transaction systems and on-line data base applications serving many users, are becoming increasingly complex. The result is that the computer resources required to run such a system are increasing.

Although earlier predictions have been off the mark, two things are certain: the cost of electronic circuitry continues to fall, and the market for computers continues to soar.

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In the turmoil of the computer industry, it is virtually impossible to extrapolate economic rules of the past to plan systems of the future. Prior trends will be reviewed here, as well as recent developments, to get an idea of where the computer world is headed.

Economics of the past. Until the early 1970s, computer economics appeared to be relatively simple. Computers were viewed as belonging to a single machine category for which the cost of hardware (usually its monthly rental charge) bore some direct relationship to the size or power of the equipment.

In the 1940s, Herbert A. Grosch stated that the cost of a computer system is directly proportional to the square root of the effectiveness of the system, in which effectiveness is some measure of performance, speed or throughput.

Researchers set out to determine the validity of Grosch's Law. One showed that there were economies of scale in the relationships between price and power of computer equipment, although the parameters of the relationship and its form were not as stated in the Law. Research also showed that technological progress caused drastic reductions, over time, in the per-unit cost of power.

Ten years later, three others questioned Grosch's Law and the subsequent empirical analysis. They asserted that such relationships were meaningless because the measures of price/performance that had been used did not provide for differences in computer markets—such as the distinction between large

general-purpose systems and smaller business systems.

One researcher claimed that the definition of computer power no longer applied to the architecture of the 1970s because of virtual memory and the trend away from tape to disk storage. The conclusion was that, for general-purpose computer systems, memory was a good predictor of system cost. A stable relationship existed between price and performance, with performance and memory capacity highly related.

For small business computers, essentially minicomputers, a stable relationship was not found for price/performance. The analysis showed, however, that minicomputer systems cost significantly less than the equivalent general-purpose configuration, perhaps because minicomputers had more specific application and did not have the same range of software, documentation and other features.

These conclusions contradicted the claim of earlier researchers that economies of scale applied for all computers. It demonstrated that smaller systems tended to have a price advantage over larger general-purpose systems. Other studies, however, indicated that advances in technology, over time, resulted in lower prices for both mainframe and minicomputer markets.

In 1978-79 some researchers were looking back at a general-purpose computer market that had stabilized by the 1970s and a small-business computer market that had not yet become stable. The market for personal computers was just being established. Although the word processing and personal computer markets had experienced rapid growth, they were still too small for serious analysis. Even as late as 1983, researchers had not fully recognized the rise of microcomputing.

Volatile marketplace. Now, in the mid-1980s, we are witnessing explosive growth in microcomputer-based workstations and personal computers, both for office and home use. In an atmosphere of competitive pressure, the home computer market is characterized by precipitously falling prices.

Such a volatile marketplace is bound to send tremors through the more established minicomputer and mainframe markets, but it is too early to determine these effects or to establish price/performance models for the new categories of equipment.

Sometimes a product is introduced, such as IBM's 4300 in the late 1970s, that contributes to significant upheaval in the marketplace for that type of equipment. Its price/performance falls below the break-even price of competitive products. In other cases, competition and technological advance bring one type of product into conflict with another. This is happening with superminicomputers and small mainframes, supermicrocomputers and low-end minicomputers, personal computers (PCs) with sophisticated word-processing software and word processors, and microcomputers and intelligent terminals.

The boundaries between products begin to blur, and predictions for growth veer from actuality as substitutions between categories raise havoc with expectations.

Where are we? What happened in the past five years to upturn the predictions of the late 1970s? The pattern that emerges provides clues to the unanticipated rise of the microcomputer and the relative lessening of the importance of minicomputers and mainframes.

The three major categories of computers—mainframe, minicomputer and microcomputer—differ for the most part by orders of magnitude. Mainframes and their peripheral devices typically cost millions, if not tens of millions of dollars for each configuration. A minicomputer configuration represents a tenth or less of that cost. Microcomputers are a tenth the price of minicomputers. There is also overlap between categories such as superminicomputers which cost the same as, or more than, small mainframes. But in general, the differences are marked between categories of equipment.

On the other hand, because the typical number of users supported by each type of system also bears the same order-of-magnitude relationship, the system cost per user is roughly the same. This was emphasized in a recent article showing the drop in cost per workstation for a shared mainframe remains competitive with the cost of a microcomputer installation. Many writers, however, predict the demise of mainframe computers and their replacement by mini- and microcomputers over the next decade.

Perhaps the most telling aspect in the rise of microcomputers, as well as minicomputers before them, is that lower hardware costs were accompanied by proportionately lower software, operational and support personnel costs. Microcomputers would have remained an engineering curiosity if their software and support were priced at the same level as for mainframes. Perhaps the main reason futurists and planners did not anticipate the rapid rise in PC sales was because of the unexpected availability of low-cost software packages and the development of equipment that could be easily operated by novices.

The drop in hardware and software costs for word processors and personal computers was possible because of the huge number of units produced. The production cost for additional copies of software packages is negligible compared to the cost of developing the initial product. The economies of scale that apply to computers are related primarily to hardware, and not to overall operations.

Where are we going? The glib answer is: "Not where we expect!" Earlier predictions have been, for the most part, wildly off the mark. Two things are certain, however: the cost of electronic circuitry continues to fall year after year,

Predicted Growth in Annual US Shipments

Equipment Category	1982 Shipments $BN.	%	1987 Shipments $BN.	%	5-Year Increase, %	Approx. 1-Year Increase	Start Period of Significant Sales
Mainframe (General-purpose computer)	11.9	42.5	15.2	26.2	28	5	Early 1960s
Small Business Computer	1.8	6.4	2.9	5.0	61	10	Mid-1970s
Terminal	3.5	12.5	5.8	10.0	66	11	Late 1960s
Mini-computer	3.9	13.8	7.6	13.3	95	14	Late 1960s
Word Processor	2.2	7.9	4.3	7.4	95	14	Late 1970s
Super-mini-computer	0.8	3.0	2.6	4.7	250	29	Early 1980s
Personal Computer	3.9	13.9	19.4	33.4	397	38	Late 1970s
TOTAL	28.0	100.0	58.0	100.0	107	16	

Source: Data in this chart supplied by International Data Corp.

New Economics of Computers

and the market for computers and computer-related products continues to soar.

It is clear that the developments of the recent past—resulting in the proliferation of remote workstations operated by non-data-processing (DP) personnel—will greatly alter the economies of hardware/software/personnel. This makes it almost impossible to measure the personnel component in particular because the primary function of individuals who program and operate microcomputers increasingly will not be DP.

The table in this article shows the major equipment categories for US products in 1982, and predictions for 1987. The categories have been ranked according to increases in annual shipments. The one-year increase is a percentage that, with annual compounding, leads to the five-year increase.

Two patterns appear in the predicted growth figures. First and foremost, there seems to be a strong relationship between the percentage increase in shipments and the period during which the product became well-established. Products introduced prior to the mid-1970s generally show much smaller increases in shipments than products introduced within the past five years. As products mature and their markets become saturated, their potential for growth is reduced.

Secondly, over the 1982-1987 period, the share of total shipments for old-line products falls from three-quarters of the total to about half. Although all categories of equipment are growing steadily, the differences in growth rates—if sustained—will lead to major changes in the breakdown of equipment markets by 1987.

The chances that the patterns presented in the table will eventually occur are remote. Two trends point to a slowdown of the growth rate in the superminicomputer and microcomputer markets.

First, we saw downward revision in the sales estimates for home computers—in one case, from seven million to five million units in 1983. Secondly, IBM introduced a series of general-purpose mainframe computers that compete directly with the superminicomputers. These developments suggest that some growth anticipated for the superminicomputers will fall to the equivalent general-purpose machines, and that the microcomputer market may be showing its first signs of saturation.

I would estimate that the total dollar volume of shipments predicted in the table will be realized in 1987, but that percentages will lean toward the general-purpose mainframes and small business computers.

The flaw in computer market forecasts arises because fully half of the projected 1987 market consists of products that did not exist five years ago. It is fair to state that many of the products and services (possibly 50 percent or more) that will comprise the computer marketplace 10 years from now either do not exist or play a very minor role in today's market. Consequently, the pure projection of current trends is not a satisfactory model.

The demand for computing. Basically there are two types of demand for computer services. One is the demand for existing services; the other is a latent demand for services that are not yet available at any price.

The demand for existing services has been shown to be price elastic. As the price/performance of computers has improved, total demand has increased proportionately.

IBM, for example, introduced a desktop computer, the 5100, almost a decade ago for about $20,000. It had minimal market acceptance. The IBM PC, introduced two or more years ago for about $3,000, has been a runaway success, partly because of its greater cost-effectiveness and the availability of low-cost peripherals. Easy-to-use versatile software has been another factor in its success.

'Computer power is not a good basis for categorizing computer resources.'

The demand for existing and potential computer services is changing over time as developed economies move from industrial to information (or service) sectors. That demand translates into the acquisition and operation of systems. The user demand is affected by an allocation system that matches demand to the available supply of resources such as mainframes, microcomputers and calculators.

The allocation process depends upon the value of the work to be done (which varies with turnaround time, response time, development time and probable distributions of these times) and the cost in providing these services.

The supply side. The key to the supply side of computer resources can be seen in the major equipment categories which differed in price by an order of magnitude. As mentioned earlier, however, categories sometimes overlap. The most sophisticated calculator costs more than the cheapest home computer. Small mainframes may be virtually equivalent in power to superminicomputers and cost about the same.

Technological advances continue, making for increased power and improved price/performance within each category. To quote the president of Texas Instruments, J. Fred Bucy: "As the cost of computing gets cheaper, it is likely that the more powerful desktop computers will start moving through marketing channels developed by the company's consumer group." This means that in a few years the home computer, while still priced in the hundreds of dollars, will have the capacity and features of today's personal computer which costs thousands of dollars, and so on up the line.

It would seem, then, that computer power is not a good basis for categorizing computer resources. By looking at price and the cost of support and software, the size of organizations that can acquire the equipment can be determined.

In addition to this vertical categorization of computer resources, a horizontal spread extends to data communications, process control, robotics, artificial intelligence and so on. These aspects of computing can be considered extensions to the commercial and scientific data processing functions. As price/performance of circuitry improves, extensions of processor technology become feasible.

The economics of computers prior to the mid-1970s no longer holds. The computer revolution has brought about societal changes that are moving us from an industrial to an informational world. This trend is creating new demands for computing.

Technology is advancing quickly to provide price/performance characteristics that enable products to be offered over an almost continuous range. With high-end processors becoming more and more powerful, increased power trickles down through all the smaller categories of equipment. As the market expands, the high cost of software development can be spread over more units. This creates additional demand because cheap software increases the value of equipment.

The new economics of computers can be explained in terms of the present and even used to anticipate short-term trends. But the acceleration in innovation makes it almost impossible to predict the marketplace of the future. (IN)

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